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Original communication

Diatomological mapping of water bodies – A future perspective

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ABSTRACT

Corpse floating in running or stagnant water may not keep a tail of its exact place of drowning. Disagreement between diatoms recovered from the body and those in the presumed drowning medium may possibly advocate that body has been moved from its exact site of drowning. It emphasizes on the importance of water sampling from where the body is found. Diatomological Mapping (D-Mapping) of water bodies assumes to be an important means to solve this problem even when reference water sample is not available. Information of the present attempt has been exercised to scratch the authenticity of D-maps of these four water bodies after a gap of four years (2007–2011). Current records have been found interesting and significant for the authenticity of D-maps for a prolong characterization of water bodies.

1. Introduction

The task in drowning cases remains focused mainly on establishing whether the individual was alive while entering into the water also called ante-mortem drowning. Diatoms play a very useful role in solving these types of Medicolegal cases.[1,2] "*Diatom test*" which is an examination based on screening of diatoms from the vital organs of the deceased, represents one of the most valid tests for establishing ante-mortem drowning even in skeletonized bodies.

Diatoms are microscopic single celled algae that can inhabit both fresh and salt water. Thousands of different diatom types exist with beautiful symmetric geometries and intricate nanoscopic features in their porous silica shells. There is large variation in their size and shape.[3] There is no natural occurrence of diatoms in the human body. The size of this tiny phytoplankton ranges in micron meters which is worth for its passage via lung alveoli through blood circulation in the distant body organs in ante-mortem drowning. Inhalation of water causes deposition of diatoms in brain, kidneys and other body organs.[3–7]

The 'diatom test' may be considered positive for the investigation of drowning cases when analyzed in relation to the season and month of drowning, if possible. Variation in the climatic conditions prevailing on any water body of any place can have a gigantic effect on the occurrence of diatoms. So, exclusion of possible mistakes should be avoided and '*criteria of concordance*' should be fulfilled while conducting 'Diatom test' in the laboratory.[6,8] Both, qualitative and quantitative criteria are essential to assess the reliability of the diatom test.[9–12]

Occasionally, question regarding localization of the precise site of drowning can be an important medicolegal issue.[4–7,13,14] Sometimes, drowning cases is encountered with the unclear situation on the exact site of drowning especially when drowned body is replaced to land or drowned body has dragged to a greater distance from the exact site of drowning with swift flow of water. Another situation can also be thought when significant numbers of diatom frustrules are found in the body organs but they do not match with types of diatoms from reference liquid medium.[15] In these situations locating the putative or the exact site of drowning becomes the prime job of a forensic expert. The analog matching of diatoms can provide information on the most associated sites of drowning.[2,5,13,14,16–18]

Use of a reference diatomological database of water bodies was recommended of immense help for correlation purpose in these types of cases.[3,19] Earlier, validity and utility of the diatom tests for drowning was established based on the examination of 771 cases of drowning together with the match of diatom in bone marrow with diatoms of drowning medium.[5] This database can be obtained either by '*continuous river monitoring of the diatoms*'[13] or by generating '*D-maps*' of water bodies.[14] These methods keep a record of various commonly occurring, seasonally occurring and site-specific diatom species which ultimately characterize water bodies and prove cursors in correlating with diatom species recovered from the drowned body. Question regarding the diversified

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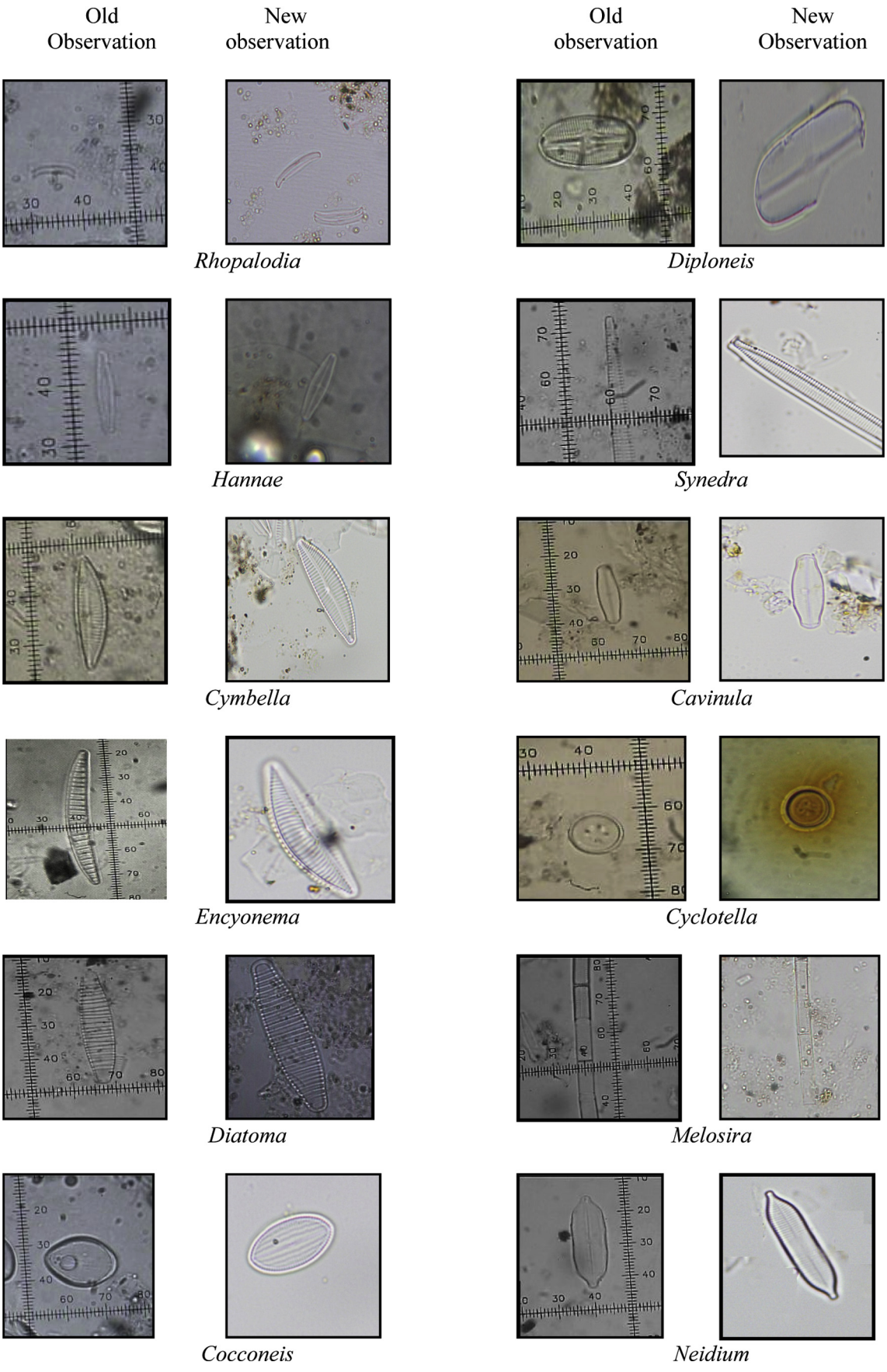

Fig. 1. Comparative view of old and new diatomological observations.

occurrence of diatoms can be answered after discovering their growth factors. Since the growth of diatoms is bound to surrounding climatic conditions, nutrient factors and some chemical properties of water therefore, diatom community can vary in different water body and even in the same water body at different locations.[2,14,20]

In recent years, water samples of the ten water bodies including lakes, ponds, rivers and canals were analyzed for two consecutive years comprising four different seasons to generate D-maps of these water bodies. Not all but few water bodies produced some consistently occurring site specific diatoms. Application of D-Mapping has been suggested of immense help in solving drowned cases where no reference water body is available.[14] For the verification of old diatomological record, four water bodies, which were monitored earlier[14] in 2005–2007 have been retraced in the present study. This is a seasonal revised study of same water bodies to ascertain authenticity of the D-Maps.

2. Materials and methods

Following four water bodies were chosen for re-examination. The basis behind choosing these water bodies was occurrence of some site specific diatoms in the past.

1. Sukhna Lake Chandigarh (SLC-1)
2. Kanjli Wetland, Kapurthala (KWK-2)
3. Sutlej Water Body, Ropar (SWBR-3)
4. Guru Nanak Dev Thermal Plant, Bathinda (GNDTPB-4)

3. Collection and analysis of water samples

The water samples were collected from the all sides of the selected four water bodies covering summer (June), autumn (September), winter (December) and spring (March) seasons in 2011–2012. The dates of present sampling were kept according to the previous schedule.[14] Water samples were filled with serially marked plastic bottles. About 200 ml water sample was taken for the extraction of the diatoms using Acid Digestion method (Nitric acid). The samples were kept undisturbed for 2 h after adding with 40 ml conc. Nitric acid. The samples were then centrifuged at 3000 rpm for 10 min. The supernatant was discarded and the residual material was used for the further analysis. The residual material was put on serially marked microscopic slides (5 for each side of the water body) and these slides were permanently mounted with DPX solution. Slides were examined at high magnification with the help of an optical compound microscope. The photomicrographs were captured using a computerized photo capturing device/camera fitted on this microscope. Diatom species were identified on the basis of available literature.[21,22] The photomicrographs of diatoms have been shown in Figs. 1 and 2. Diatomological database of the present study was used to compare with the D-Maps as illustrated earlier.[14]

4. Results and discussions

D-Maps of four chosen water bodies have already been worked out from 2005 to 2007.[14] Now, after a gap of four years, verification of that record has been made in 2011-12. Climatic conditions and pH of water

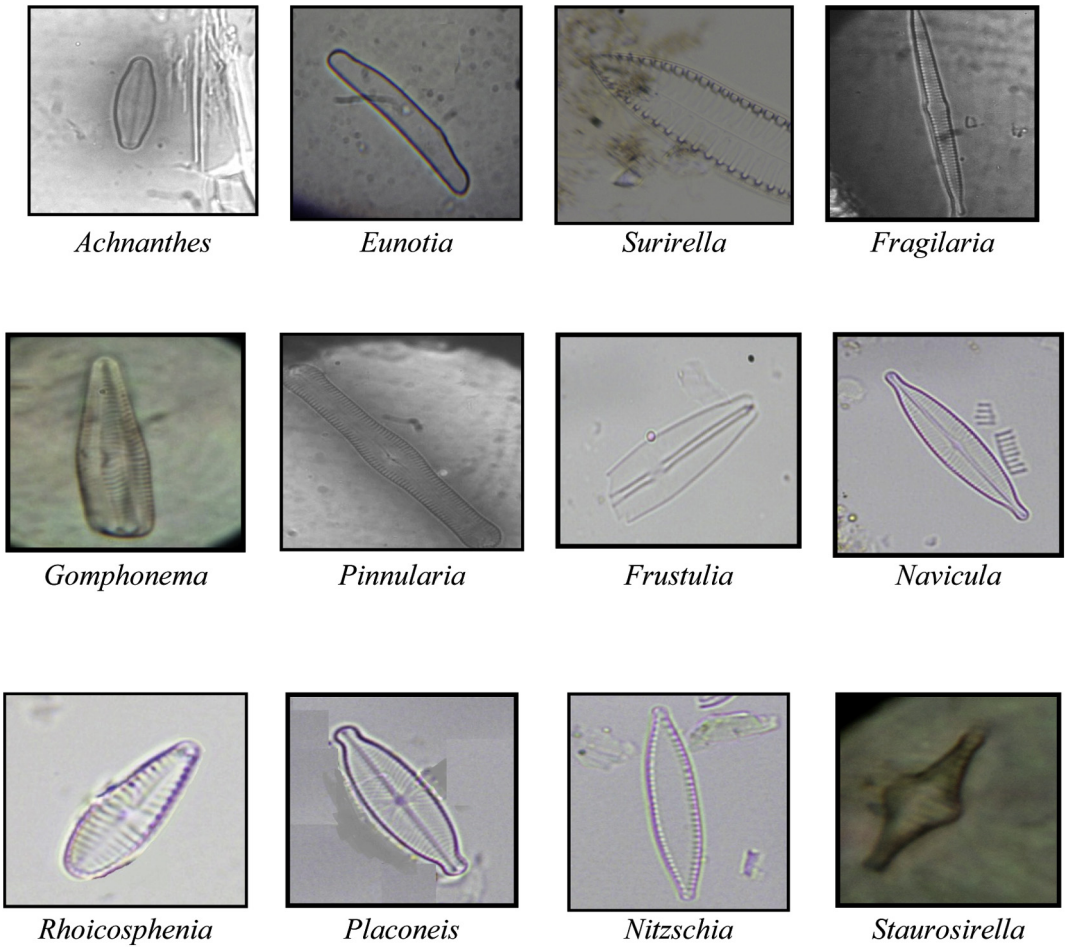

Fig. 2. Photomicrographs of some other diatoms.

samples at these localities generally remained almost unchanged. Some concurrence findings have been noted. A full bloom of diatoms has been recorded in the spring season when climatic conditions are best for the proper growth of the majority of diatoms. Winter season made a '*dilution effect*' on diatom population yet again. Mostly, 'pennales' diatoms have been seen and *Navicula*, *Nitzschia*, *Cyclotella* and *Synedra* were identified as commonly occurring diatoms while *Melosira* was infrequently seen. Diatoms such as *Aulacoseira*, *Pseudostaurosira*, *Stauroneis* and some preceding site indicator diatoms such as *Cymatopleura*, *Didesmis*, *Gyrosigma* and *Geissleria* did not occur this time.

No major changes have been observed in the current results in comparison to the past diatomological record in SLC-1. Previously observed *Rhopalodia gibba* and *Hannaea arcus*[14] two site specific diatoms of SLC-1 have also been noticed consistently in all seasons. Present screening of diatoms has also viewed species of *Navicula*, *Achhnanthidium*, *Synedra*, *Epithemia*, *Cyclotella* and *Nitzschia*. *Rhoicosphenia* and *Encyonema*, the seasonal diatoms of previous study were observed this time also. Recurrent of some imperative diatoms and their association with the past diatomological record positively assures authenticity of the D-Maps of this water body.

Diatoms in KWK-2 were as usual highly diversified and in large amount but there was a slight change observed in comparison to a previous diatomological database of this water body. In the category of site specific diatoms, *Neidium* was yet again noticed while *Diadesmis* disappeared. Earlier named commonly occurring diatoms such as *Cyclotella*, *Cymbella*, *Diatoma*, *Pinnularia* and *Synedra* also occurred but *Amphora* was unnoticed. A present occurrence of a variety of sturdy *Pinnularia* species was a characteristic observation of this water body. Correlation of the present findings with old record could be made out to some extent only. Many large size diatoms with a considerable amount were consistently present in all collections of SWBR-3. *Amphipleura*, *Gomphocymbella*, *Cymbella*, *Gomphonema* and two earlier seasonal characteristic diatoms *Diploneis* and *Placoneis* were also seen. *Navicula* and *Nitzschia* were present in large number while *Eucoccoenis* was unseen in all seasons. Although, some seasonal diatoms remained unseen but recurring of some characteristics diatoms has held the authentic behavior of D-Maps of SWBR-3. The lowest population of diatoms in all seasons is a comparable observation of GNDTPB-4. Diatoms were least diversified and hard to see in this water body. Recurring of *Surirella*, a preceding characteristics diatom of this water body had been a remarkable observation of the present study while vanishing of *Campylodiscus* was equally notable. A few species of *Cyclotella* and *Melosira* were found. Observations of this water body have ascertained authenticity of the D-Map even in the least diatom populated water bodies. The photomicrographic comparative analysis of old and new diatoms and photomicrographs of some other diatoms of the current study have been figured as Figs. 1 and 2.

5. Conclusion

The findings of the present study have proved the recurrence of diatoms in different water bodies. It is really noteworthy to see the correlation of present observations with the preceding database of the same water bodies. Therefore, the surveillance of the present study encourages D-Mapping for the forensic characterization of water bodies for a prolonged time.

Ethical approval
None.

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Conflict of interest
None declared.

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References

1. Peabody AJ. Diatoms in forensic science. *J Forensic Sci Soc* 1978;**17**:81–7.
2. Pollanen MS. The diatom test for drowning in Ontario. *J Can Soc Forensic Sci* 1996;**29**(4):205–11.
3. Thakar MK, Singh R. *Diatoms*. In *Wiley encyclopedia of forensic science (UK)* 2009;vol. 2748–57.
4. Siver PA, Lord WD, McCarthy DJA. Forensic limnology: the use of freshwater algal community ecology to link suspects to an aquatic crime scene in southern New England. *J Forensic Sci* 1994;**39**:847–53.
5. Pollanen MS, Cheung L, Chaisson DA. The diagnostic value of the diatom tests for drowning. I. Utility: a retrospective analysis of 771 cases of drowning in Ontario, Canada. *J Forensic Sci* 1997;**42**:281–5.
6. Krstic S, Duma A, Janevska B, Levkov Z, Nikolova K, Noveska M. Diatoms in forensic expertise of drowning – a Macedonian experience. *Forensic Sci Int* 2002;**127**:198–203.
7. Cameron NG. The use of diatom analysis in forensic geosciences. *Geological Society, London, Special Publications* 2004;**232**:277–80.
8. Pollanen MS. *Forensic diatomology and drowning*. Amsterdam, The Netherlands: Elsevier Science, B.V.; 1994.
9. Pachar JV, Cameron JM. The diagnosis of drowning by the quantitative and qualitative analysis of diatoms. *Med Sci Law* 1993;**33**(4):291–9.
10. Polson CJ, Gee DJ, Knight B. Drowning. In: *The essentials of forensic medicine*. Oxford: Pergamon Press; 1985. p. 421–8.
11. Hendey NI. The diagnosis value of diatoms in the cases of drowning. *Med Sci Law* 1973;**13**(1):23–34.
12. Hendey NI. Letter to the Editor. Diatoms and drowning – a review. *Med Sci Law* 1980;**20**(4):289.
13. Ludes B, Coste M, Tracqui A, Mangin P. Continuous river monitoring of the diatoms in the diagnosis of drowning. *J Forensic Sci* 1996;**41**(3):425–8.
14. Thakar MK, Singh R. Diatomological mapping of water bodies for the diagnosis of drowning cases. *J Forensic Leg Med* 2010;**17**:18–25.
15. Natasha D, Aleksej D. Differential diagnostic elements in the determination of drowning. *Rom J Leg Med* 2005;**13**(1):22–30.
16. Tyagi GD, Dogra TD, Dikshit PC. Diatoms of Delhi. *J Forensic Med Toxicol* 1985;**2**(3):18–23.
17. Kazutoshi AGO, Mihoko AGO, Mamoru OGATA. The distribution of diatoms in Yoronjima and application of the diatom test for the diagnosis of death by drowning in open sea islands. *Med J Kagoshima Univ* 2004;**56**(2):25–9.
18. Singh R, Singh R, Singh R, Thakar MK. Diatomological studies from three water bodies of Jaipur. *Indian Internet J Forensic Med Toxicol* 2006;**4**(3):1–11.
19. Ludes B, Coste M, North N, Doray S, Tracqui A, Kintz P. Diatom analysis in victim's tissues as an indicator of the site of the drowning. *Int J Legal Med* 1999;**112**:163–6.
20. Trent G. Something in the water. *ProQuest Direct Complete Law and Order* 2004;**52**(6):92–3.
21. Hartley B, Barber HG, Carter JR. *An atlas of British diatoms*. Bristol: Biopress Ltd in association with the Natural History Museum; 1996.
22. Kilroy C. *Quick guide to common diatom genera in fresh waters*. Maria Temes Casas 2004.